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THE BIOLOGICAL WAR AGENTS AND CERTAIN PROBLEMS OF PROTECTION THEY NECESSITATE

Translation of an article by Carl-Goran Heden in the Swedish language periodical Teknisk-Vetenskaplig Forskning (Technical Scientific Research) vol. 34, no. 2, Stockholm, 1963, pages 55-67.

Most people are profoundly ignorant about the nature of biological warfare (BW). Perhaps the only thing that is generally known is that it is capable of hitting large groups of both civilian and military personnel, without distinction and stealthily. A result of the ignorance is that this type of weapon as a rule is dismissed with a shudder, not only free from public debate, but from the level of consciousness of our leaders of society. When BW in some exceptional cases is regarded as a real hazard it happens in an atmosphere of apathy, because the possibility of defense are on rather inadequate grounds deemed small or non-existent. Such a reaction, which has occurred at the introduction of every new weapon since the time of the crossbow, is dangerous because it plays into the hands of a potential enemy and in that way reduces the peace preserving potential of our defense.

A psychiatrist has said that the reaction of the general public to BW is similar to that of a medical student when he enters an autopsy room. He does not learn much anatomy until he has gradually familiarized himself with death. Against this background, facts will be presented that may form a basis for a certain familiarity with the BW sector. The purpose is to present an orientation to specialists and responsible authorities, and I share the opinion (1) that there is a risk the international atmosphere could deteriorate if the press on the occasion of the next big epidemic would start discussing BW.

BW, a Reality or Product of the Imagination

The biological war agents are of relatively recent date (1, 2) (Table 1). Actually the American civil defense administration (FCDA) judged the risk of attack with biological and chemical

war agents to be small as late as the fall of 1958. Since then however a reevaluation has apparently taken place, as a result among other things of some special reports (3, 4) which placed the biological and chemical war agents in the same class as the nuclear weapons. In this connection it has among other things been pointed out that the politico-military decisions now have become strongly dependent on the civil defense potential, which during the epoch of manned bombers and small weapons not decisive in the same way as it is now. Actually a high military potential is now regarded as being of small value unless it is supplemented by a good defense against BW as well as against atomic weapons and chemical warfare (CW).

It is probably the results of tests and war games that have been carried out that form the direct background for the reappraisal. Thus a war game in Asia appears to have attracted a certain attention (5). The starting point is said to have been a simulated Chinese attack far into South Vietnam directed towards the capital of Cambodia, which it is presumed the Chinese would reach before the American troops from Thailand. The difficulty in controlling BW was well illustrated in the analysis, which showed that the actual attack not only would have killed or inactivated 75% of the enemy troops. It would also have exposed 600,000 friendly or neutral citizens to the agents under discussion.

The Biological War Agents and Their Relationship to Chemical and Nuclear Weapons

The list of potential war agents (6, 7, 8, 9, 10) includes a number of agents that are known easily to produce laboratory infections (11). It includes about a dozen bacteria (e.g., anthrax (12), contagious abortion, glanders, tularemia (13), pest (14), erysipelas, cholera and tuberculosis bacteria (15), some fungi and protozoans (e.g. pathogenic agents of coccidiomycosis (16), histoplasmosis (17), amebic dysentery and malaria), a group of viruses (18) (e.g. the agents of contagion for influenza (19), psittacosis, Venezuelan equine encephalomyelitis, yellow fever, smallpox, Rift Valley fever, Japanese B and Russian vernal encephalitis and foot-and-mouth disease). To these are added several pathogenic agents that do not directly belong in the groups mentioned (e.g. those that characterize Q-fever (20), typhus fever, Rocky Mountain spotted fever and pleuropneumonia) and a number of toxins (21), (e.g. botulin). With regard to the following it may be mentioned that these latter often are more effective if used in aerosol form than if the same dose is taken by mouth (21, 22).

Table 1

Year	General	Sea	Air	Space
1935-45	Radar	Magnetic and acoustic mines	8-gun fighter	Ballistic missile (V2)
	Flamethrowers		Flying bomb	
	Light rockets	Midget submarines	Jet fighter	
	Blockbuster	Schnorkel submarine		
	Infrared devices			
	Proximity fuze			
	A bomb			
1945-55	Napalm bomb		Jet bomber	
	H bomb		Supersonic figher	
	"Tactical" nuclear weapons			
1955-65	50 MT bomb		Antiaircraft missiles	Long range ballistic missiles
			Supersonic fighters	Solid fuel missiles
1962	Biological and psychochemical weapons		Airborne ballistic missiles	Reconnaissance satellites
				Satellite bombers
				Anti-satellite devices

In other words one is confronted with at least 20 to 25 agents that it is necessary to recognize, and to this must be added variants produced by genetic manipulations. Some of the pathogens listed can however be placed far down on the list of probable war agents, which of course simplifies the situation. The reasons may be many. For example as regards a disfiguring disease like smallpox that an attacker hardly would want to create a permanent memorial to its biological warfare technique (5). Other reasons may be that the natural immunity of the target population is high or that effective preventive methods are available (immuno- chemo- and antibiotic prophylaxis). The possibility that the enemy may be using resistant mutants (23, 24) must however not be forgotten in this connection.

The doubts formerly presented about the effectiveness of some of the pathogenic agents against humans are without foundation, as to the series of experiments on humans concerning for example Rickettsia tsutsugamushi via the dog (25), Plasmodium vivax via the bloodstream (26), Brucella abortus (27), intestinal bacteria (28, 29) and poliomyelitis (30) by mouth, there have now been added regular aerosol experiments. Thus for example the aerosol dose for humans of rabbit fever bacteria (Pasteurella tularensis) has been determined to be 25-50 cells (13, 31). With regard to the causative agent of Q-fever (Coxiella burnettii) apparently a single particle is sufficient to produce infection (20) and here it has been found that one billion human infection doses are contained in one gram of infected chicken tissue (32). It is such figures for the effectiveness per unit of weight, as well as the modest cost of production and the possibility for anonymous use that serve as justification for the biological war agents sometimes being labelled 'weapons of the future." To this may be added an aspect that even more frequently appears in the press (33). The circumstance that some of the chemical and biological war agents may be characterized as humane is in some cases they may produce a high morbidity and low mortality (5, 34, 35). However surprizing such statements may appear at first, one must say that they are understandable when they are seen from the perspective of grenade injuries, napalm and atomic bombs. A geneticist would certainly also prefer biological to atomic warfare, whose biological consequences as we know are not limited to a single generation.

In table 2 and 3 the biological war agents have been correlated with A and C weapons. The tables have been based on a compilation made by the Civil Defense Committee of the American Chemical Society (3). It presupposes that a bomber of the type B52 can carry a 20 megaton thermonuclear bomb, or enough chemical or biological war agents to produce equivalent results to the upper part of table 2.

Table 2

	Nuclear agents	Chemical agents	Biological agents
Immediate effective area	75 to 100 sq miles (A & B rings)	100 sq miles	34,000 sq miles at very least and with only 45 lb of agent
Human lethality (or morbidity) in immediate area (unprotected)	98% (lethality, H ring)	38% (not necessarily lethal)	25 to 75% (morbidity not necessarily lethal)
Residual effect	6 month fallout within additional 1000 sq miles of area	3-36 hours (nearly same area)	Possible epidemic or epizootic spread to other areas
Time for immediate effect	Seconds	7½ sec to 30 min	A few to 14 days
Real property damage, immediate area	Destroyed (nearly 36 sq miles)	undamged	undamaged
Variation in effect	Little	Wide, need not kill, only incapacitate immediately	Wide, need not kill, only incapacitate
Time aggressor can safely invade area after attack	3-6 months	Immediately	Immediately after incubation period
Human protection that could be available	Evacuation (?) shelters, civilian mask (fallout)	Civilian mask CDV-805, shelters with filters	Civilian mask CDV-805 immunization, shelters with filters

Table 3

	Nuclear	Chemical	Biological
Current defense for US population (physical devices)	Some, but can be greatly improved	Nearly nonexistant	Nearly nonexistent
Cost of protection	Shelters ($150 to $800 per person	Mask ($2.50 to $8.00) filters on shelters ($15 to $30 per person)	Mask ($2.50 to $8.00) filters in shelters ($15 to $20 per person) immunization (?)
Possibility for covert application	Little	Some	Great
Detection and identification	Simple	Complex but fairly effective and rapid	Difficult, complex, slow
Medical countermeasures	Little	Good if immediate	Some, much more needed. High health and sanitation standards help
Would attack trigger retaliation?	Yes	Yes	Doubtful if covert, slow at most
Capital equipment costs to produce agents	Very expensive	Somewhat expensive	Relatively inexpensive
How agent attacks target	Direct impact, then some "seeking" with fallout	"Seeks" out target	"Seeks" out target

The Aerosol Attack

The problem of how we can protect ourselves against biological attack is extremely difficult because the ways of attack are many (7, 36, 37) and an attack may very well be launched in time of peace. I shall here omit the protection against sabotage contamination of food products, feedstuffs and water and against the spreading of disease carrying vermin, as these kinds of attack are exhaustively elsewhere (6, 38, 39). Instead I shall here discuss the aerosol attack and the special protective problem it poses.

The immediate effective area for biological war agents indicated in table 2 has evidently been calculated on the basis of an American simulation experiment, when 8.6×10^{25} fluorescent particles of size 2 μ (zinc cadmium sulfide) under suitable meteorological conditions (sea wind plus inversion) is spread from a vessel along a course about 250 km long and about 15 km from the shore (40). The distribution path of the cloud was followed about 725 km and it covered, as the table indicates, about 88,000 square kilometers. Within this area the smallest inhaled dose was 15 particles and the greatest 15,000.

To give a clear idea of the magnitude of the areas covered in this experiment these have been transposed to a map of Sweden (Fig. 1)

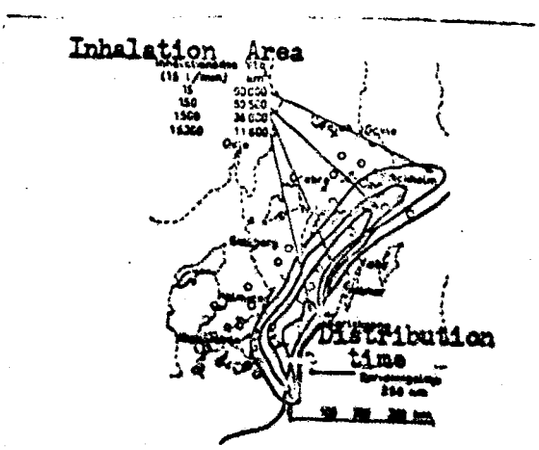

Figure 1. Testing material: about 200 kg zinc cadmium sulfide particles (2 μ) The circles indicate sampling stations, and the heavy contours the distribution in the American experiment

It is true that the immediate effective area in this experiment applies to a chemical substance, but the figure is confirmed by experiments with biological aerosols. In another American experiment which also has been transposed to a Swedish map (Fig. 2) about 500 liters of a spore suspension of Bacillus subtilis var. niger was dispersed from the rear deck of a ship that travelled along a course about 3 km long and about 3 km from the coast (10). The dispersion course was at right angles to an off-shore wind (about 2.2 m/sec) and from a meteorological point of view the situation was characterized by a slight lapse condition (i.e. not the stabilizing so-called inversion condition) and by 100% relative humidity (bacteria often do better while certain viruses have poorer resistance at high atmospheric humidity (41). A number of sampling stations were placed in the homes of officials and in various government offices and buildings within the area, which may be regarded as an illustration of the ability of fine particle aerosols quickly to penetrate for example into dwellings i.e. to seek their targets (42). The cloud was followed about 37 km in the wind direction, and distribution with attainment of infectious doses could be observed within an area of at least 260 square kilometers.

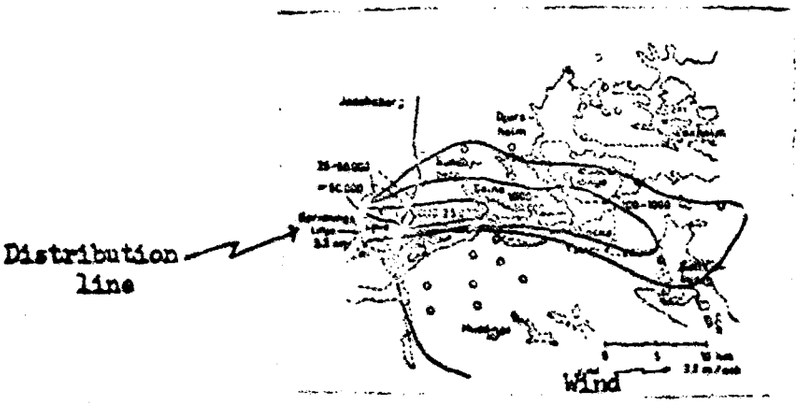

Figure 2. Testing material: About 590 liters suspension of B. globigii spores. Only 5% of the particles in the initial cloud were in the 1 to 15 μ class. The figures indicate inhalation dose at 15 liters per minute. The circles indicate sampling stations and the heavy contours distribution in an American experiment made under some inversion and fog (rel. humidity 100%)

The experiment just mentioned may perhaps be criticized from the point of view that a relatively resistant spore is involved. One can however cite the fact that a guinea-pig has been infected with vegetative bacteria that had travelled nearly 25 km in aerosol form (10, 42).

It is worth pointing out that common commercial aerosol nozzles were used in the actual experiment and that only 5% of the particles were of the order of magnitude that is most effective (43, 44) to produce infection (0.001 - 0.005 mm diameter) a type of particle that normally hardly occurs in nature (45), since they mainly arise from dilute suspensions that are acted on by great forces in fine nozzles (46). If we figure that not harmless bacterial were involved but the similar anthrax bacteria, we know from animal experiments that particles 0.012 mm in diameter give an infection dose that is at least 17 times greater than required by a one cell aerosol (on guinea pigs about 23,000 cells) (10). Concerning other pathogens (Pastourella tularensis, Coxiella burnetti and Venezuelan equine encephalomyelitis) one finds a difference of several thousand in the required infection dose when aerosols with 0.012 and 0.001 mm particle diameter are compared (10).

If a military trained saboteur (presumably very early in the morning in consideration of climatological conditions (47) lays out an aerosol beyond Lovo, as in Fig. 2, we should in other words reckon with his using equipment that is highly effective as regards producing fine particle aerosols. If he uses anthrax bacteria a few hundred liters of spore suspension would evidently be sufficient to produce catastrophic effects, even if the line of dispersion as here is only a few kilometers long. It should not be necessary to point out that he would be able to cover a many times greater area by lengthening the line of dispersion, for example by connecting the aerosol generator with the exhaust pipe of a car. If the saboteur uses other war agent than anthrax bacteria the required volume can be reduced substantially (table 4). A so dramatic reduction in volume as the figures in the table indicate (48) will hardly be considered, as the actual infective agents often are deactivated relatively soon in the air, a situation that must be compensated for by increased density of the initial cloud or by other special measures (49). If for example the sensitive tularemia bacteria were used (50) where we know that the infective dose lies at about 25 cells, the effect would have been extremely great even under the assumption that the disease producing ability for humans decreases at the same rate as for guinea pigs. Initially the infection dose then lies at 10-20 cells, but it increases to about 150-200 when the aerosol is five and one half hours old (49). In that time the cloud in the actual aerosol experiment would have passed the target area and the population would have been infected.

Disease symptoms (fever, headache, chills, sore throat, muscular pains and pains behind the breatbone etc) would however not start to appear until after 3-5 days (13) so the saboteur would have ample time to disappear out of the country.

Every estimation of the ratio of weapons [illegible] to effect is difficult, but from what has just been said it should be apparent that the biological war agents, especially if they are used in dressed form, are in a special class. It should be obvious to everyone that the apparatus required for limited attacks, for example on the Parliament building, the government offices and military staffs is minimal and probably could be placed without too great difficulty in the vicinity of air intakes.

Table 4

Botulinus A-toxin	$2{,}4 \times 10^{9}$ MLD
Anthrax	
$0{,}8 \times 1{,}3\ \mu$	$6{,}6 \times 10^{7}$ LD_{50}
$1{,}0 \times 1{,}5\ \mu$	$3{,}6 \times 10^{7}$ LD_{50}
Brucellos	
$0{,}5\ \mu$ (diam.)	$1{,}3 \times 10^{12}$ LD_{50}
$0{,}7 \times 2{,}0\ \mu$	$1{,}1 \times 10^{11}$ ID_{50}
Tularemi	
$0{,}2\ \mu$ (diam.)	$1{,}2 \times 10^{14}$ LD_{50}
$0{,}2 \times 0{,}7\ \mu$	$2{,}3 \times 10^{13}$ LD_{50}
Venezuelan equine encephalomyelitis	
$0{,}2\ \mu$ (diam.)	$1{,}2 \times 10^{16}$ ID_{50}
$0{,}5\ \mu$ "	$7{,}5 \times 10^{14}$ ID_{50}

Effect (no. doses) per ℓ active substance as administered to guinea pigs by lungs.

The possibilities for variation of an attack of this kind are so many that the protection requires a maximum of attention. It may for example be mentioned that a saboteur, in addition to the aerosol technique also may be imagined to use insects as carriers of infection. In the vicinity of an air base located in a relatively [illegible] free area in Florida for example, 200,000 mosquitoes were released experimentally according to information (5). It was found that within a few days a large portion of the personnel at and around the base experienced several bites. If the mosquitoes had been carriers of yellow fever the majority of the inhabitants would have been infected (51). Judging from experiments with volunteers it can be imagined that also malaria (52) may be used in similar situations, as well as dengue fever which we know can be produced by a single mosquito bite (53, 54). American military biologists are said to have made a pioneer contribution as regards mass production of insects for BW purposes (5) but one must presume that the technique also has been mastered elsewhere. Thus it is said that the Japanese in Manchuria many years ago reached a capacity of 45 kg pest fleas every 4 month period, corresponding to about 135 million individuals. Towards the end of World War II it was even planned to quarduple this productive capacity (55).

The biological war agents are perhaps primarily strategic weapons, partly because of the long incubation period before they take effect, partly because they can cover very large areas, perhaps even the entire territory of a great power (56) at least if they are used in the form of fine particle aerosols. The dissemination of these is not influenced noticeably by forest vegetation, rain etc. (47). Whether the greatest threat lies in a potential deadly effect on humans or in undermining the economy in that the attacker destroys the harvest (57) and reduces the stock of domestic animals (58, 59) is a debatable subject. Since I am a physician I pass by the latter aspect however, and leave it to the reader to imagine for example the effect of a sneak attack by submarine outside the coast of Scania. It may be imagined in such a case that the enemy would use viruses that produce East African swine fever, hog cholera, Rift Valley fever, cattle plague, foot-and-mouth disease, fowl plague and Newcastle disease or bacteria that produce anthrax, contagious abortion or glanders (8).

Problems of Aerosol Protection

If one asks how a defense against biological aerosol warfare can be organized, one soon finds that it must be along three lines: (1) to protect the target population prior to exposure, (2) during the period between the attack and appearance of cases of illness to take suitable countermeasures, (3) to prepare catastrophe medical care (60, 61).

The problem of warning the population within the target area in time prior to an attack is difficult, but it can theoretically be solved in various ways. But these all presuppose a network of warning stations that are capable of quickly detecting the color, odor and tasteless war agent we are here concerned with. Normal sampling procedures (62) do not suffice for this, but one must think of fully automatic apparatus continuously registering for example the protein or nucleic acid level of the air (62) and/or the content of particles of a certain order of magnitude. This is in itself a difficult problem, and it becomes almost insoluble if one works with a countrywide network of warning stations. Even if the meshes in such a net have a closeness adapted to the value of the target, it is obvious that the number of stations will be so large that the equipment must be simple and inexpensive, a demand that ought to constitute a real challenge to the chemists, physicists and teletechnicians of the country.

Figure 3 illustrates a network of equilateral triangles where sector A is adapted to a big city with a center that is of vital importance from the point of view of total defense, sector B is for a larger industrial city, C for an important industrial or agricultural district and D for the countryside within a probable target area. Now if d for example is 1 km, one will with a wind velocity of 2 meters per second have 8 minutes' respite in the center of sector A, but with a wind velocity of 20 meters per second the time has been reduced to 50 seconds. Obviously in such a situation the analysis must be carried out and the alarm set off within 30 seconds and the gas masks, which by the way provide excellent protection against this type of attack (42) must be available within reach in 20 seconds. Since this requirement can probably not be met, d must be increased, and with it also the size of the primary exposed population. How large it must be cannot at the present be estimated, but so much is evident, that it will present medical problems.

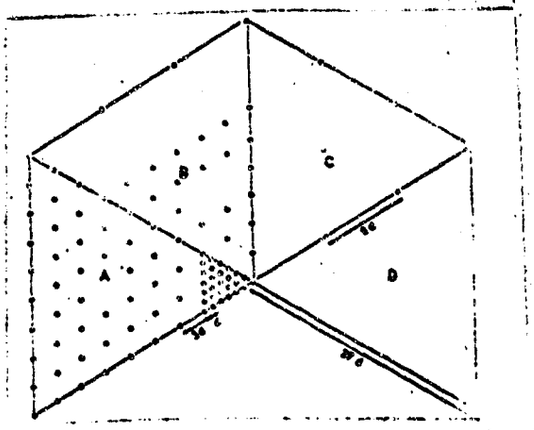

Figure 3. Network of warning stations for different population densities.

Let us now try to speculate about how the first line of BW protection may function in detail.

When a station in the warning network gives the signal, the central command sends out special plane or motorcycle patrols for sampling. This is done according to two principle (a) for quick collecting of material from the warning unit in question, for identification and (6) to map the aerosol cloud by means of helicopter carried sondes for particle counting. During the operation available data on wind direction, wind velocity, inversition etc. are processed and the sampling is directed by radio. Certain procedures may possibly also be initiated for the purpose of rendering the aerosol cloud harmless, but these cannot be discussed here.

If one or more additional stations in the warning net give the signal and meteorological (64) and military information does not make an attack improbable, the central command will release alarm signals by telephone and siren within the estimated target area.

The identification is started as soon as the aerosol sample arrives at the laboratory. It includes quick diagnosis by means of fluorescent antibodies and bacteriological and virological diagnosis by conventional methods, e.g. typing by means of specific sera and phages. In connection with this infrared absorption spectra may possibly be studied and the material may be cultured for resistance determinations and for animal experiments with reference to therapeutic and prophylactic methods. The importance of a quick bacteriologic diagnosis is illustrated for example in the case of pleuropneumonia where the therapy (streptomycin, chloramphenicol, tetracycline) must be initiated within 18-24 hours after exposure if it is to have any effect (65).

We have not arrived at the second line of defense, namely measures that should be initiated during the period between the attack and the time when the cases of illness begin to occur.

As soon as the quick identification is clear and the distribution and velocity of the cloud is established, the command orders via radio evacuation and disinfection of the gas mask wearing target population, isolates the part of the population that in spite of the alarm has been infected, determines the extent and type of chemical or antibiotic prophylaxis and whether disinfection procedures are to be followed or special measures taken with regard to the exposed animal population within the target area (42).

The evacuated target population is kept together until the laboratory diagnosis has been completed and the value of various forms

of therapy determined.

Whenever the pre-requisites are lacking for limiting the effect of the attack in the manner here outlined we are restricted to the third line of defense, to create the conditions for mass madical care (60,61). These may offer mdedical and administrative problems that are as difficult as the technical problems just mentioned. It is far from certain that 100% of the target population will become seriously ill, and the importance of the ill being taken care of by the well, of the slightly affected being able to take care of themselves and of anxiety being calmed among those who are not ill can hardly be overrated (66). Panic might be one of the consequences of BW most difficult to overcome.

The treatment must to a large extent be based on the so-called broad apectrum antibiotics in tablet form and with an ample supply of such preparations a biological warfare attack with bacteria and ricketsia can be anticipated with a certain degree of equinimity. The time for initiating the treatment must however be chosen with care, at least in the case of tularemia (67) and Q-fever (32) when it is know that the effective remedy (tetracycline) only postpones the onset of the disease if it is given too soon after exposure. In addition the treatment with antibiotics must in certain cases be combined with inoculation if the effect is to be satisfactory. One knows for example that penicillin certainly protects apes against a flaring up of anthrax, but that the protection lasts only as long as the treatment continues (68). But if the animals are given protective inoculation during the treatment with antibiotics, the latter can gradually be discontinued (69). This shows that the medical protection against biological warfare is not a question of antibiotic and chemotherapy or protective inoculation but that it requires both. In the future the most effective defense against biological war agents will be active immunization, if we may believe one of the most prominent expert on BW, Dr. LeRoy Fothergill (70).

The Planning of BW Protection

Which administrative measures are now urgent if one regards BW with the same seriousness as atomic warfare? That is a question requiring consideration and I shall only list 6 sectors where efforts are required and to a certain extent can already be made.

(1) Supplementing the Medical Board with reference to protection against BW with a permanent secretariat for investigations and coordination.
(2) Equipment of the population with gas masks.
(3) Establishment of a quarantine zone system that will make it possible to divide the country in tight compartments from an epidemiologic point of view.
(4) Training of police, health and civil defense personnel in BW

sabotage control and of microbiologists, physicians and veterinarians in diagnosis and treatment of unusual diseases (travel scholarships)

(5) Security control and special training of all personnel in employment that is sensitive from the point of view of sabotage in dairies, ice cream factories, food industries, waterworks etc.

(6) Establishment of a system for utilizing effectively the research potential of the country for the purpose of solving the problems of the warning system. This should be given priority in Sweden as elsewhere (35). To this should be added research and development work making it possible to carry on laboratory studies of biological aerosols (7, 72). Finally efforts are required for the purpose of creating better vaccines against, for example, contagious abortion, psittacosis, coccidiomycosis, Q-fever and virus encephalitis (72) and unspecific immunological protective agents (of the type endotoxin, interferon etc.) and methods for their use on a mass scale (73, 74, 75, 76) e.g. aerosol vaccination with attenuated, dependent strains whose development can be interrupted in that the agents on which they have been made dependent are exposed.) The effort that is required represents a real test of strength. One must ask whether, against the background of our limited personnel resources it can be carried out within the framework of our normal research administration, which regards itself as being able to afford to employ a frighteningly large proportion of its leading specialists in writing and reading applications and reports. How this is to be avoided cannot however be discussed here.

I doubt that any microbiologist who has taken the trouble to read the report from the Florida conference on airborne infections, December 1960 (77) is ready to minimize the potential military applicability of biological aerosols. A psychologist who evaluates their effect on the will of resistance among those attacked can however surely find reasons for questioning their military importance (2). Regardless of how real the risk of BW is judged to be, one cannot however, in the absence of illustrative material in the form of military applications, request the government to assume the investment costs for a network of national scope of warning stations for BW and CW. What one on the other hand can request is that the system be studied and planned so thoroughly that only "series production" remains to be undertaken on the day when the potential of bacteriological warfare is demonstrated somewhere in the world.

In consideration of the fact that the population pressure increases more rapidly in other places than with us, and if the fact that religious and moral inhibitions are perhaps less well developed there and the hygiene is poorer than in Sweden, it is reasonable to appraise ourselves as having a certain period of grace. If it is

utilized as outlined also for such constructive efforts as vaccine research, it is possible that in addition to a better defense we will also have the opportunity to let our assistance to the developing countries include protection against biological aggression, something WHO in spite of its great resources at the present has great difficulty in providing. Neither must one forget that military biological research often has produced purely civilian benefits. The American military biological research has for example given us an extremely effective anthrax vaccine, a preparation that makes it possible to give protective inoculations against the five botulin toxins simultaneously and an extract that makes it possible to protect plants against certain viruses (35).

The desiderata enumerated above do not perhaps at first glance give the impression of being especially difficult to provide. The question is however if not the demand for quarantine zones can have such military consequences that defense planning must be revised. Perhaps the consequence of such a reappraisal will be that one will find it to be most economical in personnel and material to limit the first line of defense and put the main emphasis on pure guerilla tactics. A well coordinated resistance movement organized in time of peace, having at its disposal the entire spectrum of modern weapons, should have a high war preventing value due to the great margins of uncertainty it would impose on the enemy's operations analysts, and due to its unequivocally defensive orientation.

To get us emotionally involved in a matter it is necessary that we the aid of imagination by being able to create a picture of the situation. That is quite easy in the case for example of a railroad disaster, but it is very difficult in the case of a BW attack. Then superstition takes the upper hand and we hope the threat will disappear while we bury our heads ostrichlike in the sand. I cannot explain in any other way the fact that we did not for example draw the BW conclusions from the paratyphoid epidemic in 1953. I can hardly imagine an epidemic situation that has been closer to a regular BW attack on a small scale.

The BW Agents and the International Situation

It is of course tempting to hope that the disarmament negotiations will reduce the conflicts in the world. To the extent that they will lead to tangible results it is however still wise to view them as expressions for technical progress that makes it possible to hold the old positions with ever smaller effort. A more profound change of mind is hardly to be expected even though the untenability of the present situation is obvious to all parties.

None less than Dr. J. Wiesner, the scientific adviser to the President of the US has said: "We are confronted by a serious communication block. In conflict situations between individuals, and in conflict situations in which individuals act for nations, statements of antagonists are evaluated not in terms of the intended meanings, but rather in terms of the most threatening alternatives. This is particularly true when survival is believed to be at stake. Every proposal by either side is scanned for the hidden purpose. The entire history of the atomic control negotiations is a demonstration of this effort." This type of reaction, the strength of which, as regards nations, appears to be in proportion to the feeling of the importance of one's own form of life for the world, is well known to every psychiatrist. Erich Froman discussed this circumstance in a symposium organized by the American Academy of Arts and Sciences: "In the current discussion on armament control, many arguments are based on the question of what is possible rather than what is probable. The difference between these two modes of thinking is precisely the difference between paranoid and sane thinking."

If one now is forced to acknowledge 1) that there exists unmistakeable paranoid elements in the intercourse between nations, 2) that the "democratic" voting mechanism applied to the supranational level probably will lead to severe crises, and finally 3) that the gap bwtween rich and poor nations in all probability will increase, it is reasonable to appraise the chances for the establishment of a real world peace with great caution. With regard to BW the hypothesis has as a matter of fact been presented that the East at the disarmament discussions in Geneva intentionally keeps the attention of the West fixed on the atomic weapons and long range missiles to cover up its real offensive plan which is supposed to be based on biological and chemical warfare (78). It is not supposed to go into effect until they have built up both their offensive and their civil defense potential within their territory and neutralized the retaliatory power of the West by an atomic weapons agreement. Against such a background the unwillingness of the East to accept inspection would be easy to explain even though the production of biological war agents is extremely difficult to control (79, 80,81). It is not impossible however that the offensive BC potential of the West will be so high on the day when a nuclear disarmament agreement is signed, that the "terror balance" will persist without atomic weapons. To the extent that the BC armaments of the great powers will make a more speedy agreement on atomic weapons possible we may paradoxically regard them as a part of the efforts to keep our planet inhabitable.

Statements by prominent Russian military and political leaders are regarded as leaving no doubt that they are prepared to use biological war agents in future war (82). It is reported that Defense

Minister Zhukov in January 1957 is supposed to have said that Russia is reorganizing its armed forces in consideration of the fact that it is believed that future wars will be fought with nuclear, chemical and biological agents of mass destruction (83). In Russia there is also a very effective organization for military training of civilians (DOSAAF), which receives a comprehensive course in ABC protection (82). (20 hours of lectures, outdoor exercises in decontamination and exercises in first aid and in the use of masks and protective equipment).

How is the present balance between East and West in the area of BC? Since on this point I must limit myself to non-secret material I can only quote General Marshall Stubbs, the leading US military chemist (35) who in connection with the work on the 1962 Department of Defense budget maintained that the East is ahead of the West both in the offensive and defensive aspect, but that the US had a 5 year program that would reduce the difference significantly if it were continued (1960: 42.6 million, 1961: 54.1 million, 1962: 61.4 plus 13 million dollars for research and development work in this area). Furthermore the information was provided by the information officer that the Soviet with the aid of German scientists made some minor experiments before 1939, when besides Germany also Italy was well prepared. The real development phase was not initiated however until after World War II. Now the Russian potential is said to be such that they even are believed capable of giving assistance to the satellites in the area under discussion. It must under all circumstances be considerable, if it surpasses that of the West (84, 85, 86).

How can it be that these effective inexpensive difficult to detect war agents, which leave the material resources of the victim's intact and in some cases even spares his prduction potential, has not been used on a large scale? The question is difficult, but one may for example consider the following:

1) That the problem of one's own BW protection has not been solved, which must have a strongly deterrent effect
2) That the popular idea of biological war agents as terror weapons causes restrain, at least in countries with free dissemination of news and a democratic government
3) That the value might be relatively smaller for the great powers that are armed with atomic weapons, which at present master the BW technology, than for smaller nations, which probably wtill for some years will lack BW capability
4) That the tactical and strategic applications, for example the possibility that small forces may bring about destructive retaliation or a military vacuum (80, 81) have not yet been brought up in the discussion of military policy.
5) That there exists a sort of pactum turpae based on the incalculability

and complicated consequences of BW. These must be strongly repugnant to traditional military thinking.

How long a reprieve that is dependent on such factors can last, no one is likely to be prepared to say.

This presentation has unfortunately become quite long. T. E. Elliot has said that man cannot stand too large doses of reality, but the latitude of variation is large, and I hope I have been able to give the majority of my readers some idea of one of the weapons of modern war most difficult to appraise and which undeniably provides further argument for the demand that international conflicts of interest be solved in another way than by military operations.

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